

1                   **COOKING THERMOMETER WITH AUDIBLE ALARM**

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3           **CROSS REFERENCE TO RELATED APPLICATIONS**

4           This application is a continuation-in-part of applicant's co-pending U.S.  
5   Application No. 10/722,286 filed November 25, 2003, which is continuation-in-  
6   part of U.S. Application No. 10/218,980, filed August 13, 2002, which is a  
7   continuation-in-part of U.S. Application No. 09/677,712, filed September 30,  
8   2000, now U.S. Patent 6,431,110, the contents of which are hereby incorporated  
9   by reference.

10

11          **FIELD OF THE INVENTION**

12          This invention relates generally to a temperature measuring device for use  
13   in cooking food, and particularly to a cooking thermometer having an audible  
14   alarm to alert the user when the temperature of the food reaches a predetermined  
15   threshold level.

16

17          **BACKGROUND OF THE INVENTION**

18          Various food products must be cooked until the internal temperature of the  
19   food reaches a predetermined temperature. This is especially true with respect to  
20   meat due to health purposes and personal preference. By achieving a certain

1 internal temperature, the preparer can be reasonably certain that the food contains  
2 no living organisms which are known to have an immediate effect in many  
3 consumers. Also, the preparer can serve a dish that conforms to the personal  
4 preference of the consumer, i.e. rare, medium, or well-done without the need of  
5 cutting open the food to check or attempt to rely solely on time cooked.

6 Conventional food thermometers incorporate a sensing probe for insertion  
7 into the food. Thus, if a thermometer only indicates temperature, the food  
8 preparer must diligently check the thermometer to determine when the food has  
9 reached the desired temperature.

10 There exist various cooking thermometer type devices that provide an  
11 indicator, such as a pop-up element or color change, which indicate when a  
12 threshold temperature has been reached in accordance with a predetermined  
13 measurement. However, these devices are generally not adjustable or precisely  
14 accurate. Thus, the preparer must diligently check the indicator to determine  
15 when the indicator is activated.

16 Conventional thermometer devices used for cooking require the preparer to  
17 carefully and diligently check the device to prevent the food from becoming  
18 overcooked. Should the food preparer become distracted with other dishes, a  
19 phone call, etc. and forget to check the thermometer, reliance on conventional  
20 cooking thermometer devices may result in the food becoming overcooked and

1 possibly inedible.

2 Existing mechanical meat thermometers typically use a bi-metal helical  
3 spring in a skewer together with a spur gear assembly to turn a temperature  
4 indicating pointer. When heated, the bi-metal helical spring expands and the  
5 resulting rotational motion moves a pointer attached to the end of the spring. Bi-  
6 metal helical springs of suitable size to be used in a meat thermometer provide  
7 only a minuscule amount of force, typically only to turn the pointer, but not  
8 enough to trigger a ringing mechanism.

9 To provide an improvement over prior art meat thermometers, the present  
10 invention provides a cooking thermometer having an audible alarm and a probe  
11 which incorporates a shape memory alloy segment of wire, such as Nickel  
12 Titanium (NiTi, commonly known as nitinol), instead of the bi-metal spring used  
13 in existing thermometers. Shape memory alloys undergo a thermoelastic phase  
14 transformation in their crystal structure when cooled from the stronger, high  
15 temperature form (Austenite) to the weaker, low temperature form (Martensite).  
16 This inherent phase transformation is the basis for the unique properties of shape  
17 memory alloys, including the shape memory effect, superelasticity, and high  
18 damping capability.

19 When a shape memory alloy is in its martensitic form it is easily deformed  
20 to a new shape. However, when the alloy is heated through its transformation

1 temperatures, it reverts to austenite and recovers its previous shape with great  
2 force. The temperature at which the alloy remembers its high temperature form  
3 when heated can be adjusted by slight changes in alloy composition, mechanical  
4 working, and heat treatment.

5         The shape memory alloys also show a superelastic behavior if deformed at  
6 a temperature which is slightly above their transformation temperatures. This  
7 effect is caused by the stress-induced formation of some martensite above its  
8 normal temperature. Because it has been formed above its normal temperature,  
9 the martensite reverts immediately to undeformed austenite as soon as the stress is  
10 removed. This process provides a very springy “rubberlike” elasticity.

11         One of the properties of nitinol alloys is that they do not undergo their  
12 phase transformation at one particular temperature. Instead, the transformation  
13 begins at one temperature (known as the start temperature,  $M_s$ ) and is completed  
14 at another temperature (known as the finish temperature,  $A_f$ ). Thus, the heat  
15 deformation properties of shape memory alloys can be utilized to operate a  
16 temperature measurement device. For optimum economy of design, it would be  
17 highly desirable to provide a cooking thermometer with an audible alarm in which  
18 a shape memory alloy is simultaneously used for both an analog temperature  
19 reading and also to provide the mechanical force necessary to trigger an alarm  
20 bell.

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3 DESCRIPTION OF THE PRIOR ART

4           Yeung, U.S. Patent No. 6,230,649, discloses a meat thermometer with a  
5   mechanical alarm bell which includes a shape memory alloy probe in the form of  
6   a coiled spring. A latch is mechanically coupled to the shape memory alloy spring  
7   and releases a wind-up mechanism when the probe reaches a predetermined  
8   temperature. While the design of this device may perform the intended function,  
9   the use of a shape memory alloy in the form of a coiled spring is highly  
10   undesirable from a manufacturing standpoint. Shape memory alloys formed as  
11   coiled springs are extremely expensive to manufacture, and the production of a  
12   meat thermometer using such a spring would not be economically feasible. Also,  
13   this device has many practical drawbacks. While an alarm sounds when the end  
14   point is reached, the device does not provide a continuous indication of the actual  
15   temperature which would enable one to estimate the cooking time remaining.  
16   The Yeung device does not allow selective adjustment of the set point  
17   temperature, but rather each device is pre-set to an end temperature so that finer  
18   adjustments for individual preferences (i.e. more rare vs. well done) is not  
19   possible. If a different type of meat is to be cooked, the shaped metal alloy and  
20   associated components must be changed.

1 Other known prior art food visual thermometers include U.S. Patent Nos.  
2 4,059,997, 3,373,611, 5,312,188, and 1,918,258; and PCT Published Application  
3 No. WO 90/11497.

4 U.S. Patent No. 6,065,391 discloses an electronic chef's fork which  
5 displays the degree of doneness of food. However, it is not adjustable and gives  
6 no audible signal.

7 U.S. Patent Nos. 5,487,352 and U.S. Patent 4,748,931 disclose a pop-up  
8 temperature indicator. The devices have a meltable seal that melts at a set point  
9 causing a portion of the device to pop-up thus alerting the user that the food is  
10 done. Again, there is no audible signal.

11 U.S. Patent No. 4,083,250 discloses a food thermometer with an audible  
12 device. On reaching a set point cooking temperature, a valve opens enabling  
13 steam in a reservoir to activate a whistle alarm. This device does provide an  
14 audible alarm but requires filling and projects a hot steam upon activation.

15 U.S. Patent No. 3,778,798 discloses a food thermometer for producing an  
16 audible alarm, but it is a complex unit generally only available as a permanent  
17 part of an oven.

18 U.S. Patent No. 4,089,222 discloses a device for telemetry of the  
19 temperature of a mass undergoing temperature change, typically of a comestible  
20 being heated in an oven, and the like. The device includes a probe having a cavity

1     which receives a thermally expansive material such as wax, a displacement  
2     member responsive to pressure developed by the temperature expansive material,  
3     a sonic or ultra-sonic signal generator, a latch mechanism inhibiting operation of  
4     the audio signal generator and a rod mechanically interconnecting the  
5     displacement member with the latch so that expansion of the material in the probe  
6     cavity trips the latch mechanism to permit generation of an output signal. The  
7     device also includes adjustment means for variation in the relative positions of the  
8     latch mechanism to the displaceable member whereby the triggering temperature  
9     for the latch mechanism can be fixedly

10           U.S. Patent No. 3,830,191 is directed to a timer for various meats,  
11     including poultry, to audibly indicate when meat has been cooked to a desired  
12     extent. The container is filled with a solution which creates steam, and upon  
13     escape of the steam an audible signal is produced which indicates completion of  
14     cooking.

15           Thus, what is needed is a means for audibly alerting the food preparer  
16     when the internal temperature of the food being cooked reaches a predetermined  
17     temperature which has an economy of design not demonstrated in the prior art.

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20     SUMMARY OF THE INVENTION

1           Thus, it is an objective of the instant invention to provide a cooking  
2   thermometer having an audible alarm for alerting the user when the temperature  
3   of a substance reaches a predetermined threshold level.

4           It is another objective of the instant invention to provide a cooking  
5   thermometer probe which incorporates a linear segment of a shape memory alloy  
6   wire therein, whereby both an analog temperature indication as well as the  
7   mechanical force necessary to trigger an audible tension wound alarm assembly  
8   are provided.

9           It is a further objective of the instant invention to provide a cooking  
10   thermometer with an audible alarm that does not require filling with water or an  
11   electrical connection for operation.

12          It is still another objective of the instant invention to provide a cooking  
13   thermometer which does not require extraneous wires or cords so that the device  
14   can be used in meats on a rotating spit.

15          It is yet another objective of the instant invention to provide a cooking  
16   thermometer with an audible alarm that is adjustable and inexpensive.

17          It is a still further objective of the instant invention to provide a cooking  
18   thermometer whose threshold temperature setting can be adjusted without  
19   removal from the substance into which it is inserted.

20          It is yet an additional objective of the instant invention to provide a



1 winding means for the audible alarm of a cooking thermometer which can be  
2 operated while the device remains inserted within the substance being monitored.

3 It is an additional objective of the instant invention to provide  
4 supplemental anchoring and anti-rotation means to aid in maintaining the cooking  
5 thermometer in its originally chosen position.

6 It is a further objective of the instant invention to provide a mesh curtain  
7 attached to the device which serves to shield the device from grease and other  
8 liquids during the cooking process.

9 It is a still further objective of the instant invention to provide a cooking  
10 thermometer which does not require the changing of internal components for  
11 varied cooking tasks.

12 In accordance with the above objectives, in a preferred embodiment of the  
13 invention, a cooking thermometer having an audible alarm is provided which is  
14 entirely mechanical in operation. The cooking thermometer has a generally  
15 cylindrical housing and a substantially hollow skewer extending coaxially from  
16 the lower surface of said housing. The housing assembly includes upper and  
17 lower portions which rotate with respect to one another to wind an alarm spring.  
18 A rotatable ring is circumferentially disposed between the upper and lower  
19 portions, and is linked to a set temperature needle so that the ring can be manually  
20 rotated to select the alarm point on the indicia plate.

1           A short linear segment of a shape memory alloy wire, preferably nickel  
2   titanium, is disposed inside the skewer and fastened to the distal end. The upper  
3   end of the shape memory alloy wire is secured to a first end of a connecting wire  
4   having a second end which extends upwardly into the housing and is vertically  
5   displaceable within the skewer. The connecting wire extends out of the skewer  
6   into a wire guide member positioned in said housing proximate the skewer. The  
7   wire guide member includes a curvilinear passage therein which is adapted to  
8   allow sliding displacement of the connecting wire therethrough such that the  
9   connecting wire extends coaxially out of the skewer into the wire guide member  
10   and extends out of the wire guide member in a direction approximately normal to  
11   the skewer. The end of the connecting wire extending out of the wire guide  
12   member is fixedly attached to a gear assembly which is rotatably mounted in the  
13   housing such that sliding displacement of the connecting wire through the wire  
14   guide member causes the rotation of the gear assembly.

15           When the skewer and hence the shape memory alloy wire are heated, the  
16   shape memory alloy wire commences a phase transformation from martensite to  
17   austenite and contracts, smoothly with significant force. The connecting wire,  
18   wire guide member and gear assembly cooperate to translate the contraction of the  
19   shape memory alloy wire into rotational motion. This rotational motion drives a  
20   spur gear train which is connected to a pivoting pointer positionable over the

1 temperature indicia plate. The spur gear train provides the appropriate gear ratio  
2 to move the pointer through a predetermined arc for each degree change in  
3 temperature.

4 A spring biasing means is constructed and arranged to exert stress on the  
5 shape memory alloy wire to extend the temperature transformation range and  
6 improve and optimize the linearity of the transition. In the preferred embodiment,  
7 the spring biasing means is applied to shape memory alloy wire via the gear  
8 assembly, and comprises at least one a helical spring having a first end attached to  
9 the gear assembly and a second end attached to an anchor member in the housing.  
10 The gear assembly can include a sector gear having a plurality of teeth arranged  
11 on an arcuate outer edge and a diametric projection extending therefrom, with the  
12 projection is adapted for attachment to both the connecting wire and the helical  
13 spring. The position of the anchor member relative to the gear assembly can be  
14 altered to adjust the degree of stress exerted on the shape memory alloy.

15 Other objectives and advantages of this invention will become apparent  
16 from the following description taken in conjunction with the accompanying  
17 drawings wherein are set forth, by way of illustration and example, certain  
18 embodiments of this invention. The drawings constitute a part of this  
19 specification and include exemplary embodiments of the present invention and  
20 illustrate various objects and features thereof.



1    BRIEF DESCRIPTION OF THE FIGURES

2    Figure 1 is a pictorial view of the cooking thermometer according to a preferred  
3    embodiment of the invention;

4    Figure 2 is cross-sectional view of the cooking thermometer of the invention; and

5    Figures 3A-E are successive exploded illustrations of the internal construction of  
6    the housing of the cooking thermometer of the invention.

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1     DETAILED DESCRIPTION OF THE INVENTION

2             It is to be understood that while a certain form of the invention is  
3     illustrated, it is not to be limited to the specific form or arrangement of parts  
4     herein described and shown. It will be apparent to those skilled in the art that  
5     various changes may be made without departing from the scope of the invention  
6     and the invention is not to be considered limited to what is shown and described  
7     in the specification and drawings.

8             A pictorial view of the cooking thermometer device 10 according to a  
9     preferred embodiment is shown in Fig. 1. The device 10 has a generally  
10    cylindrical housing assembly 12 and a skewer 18 extending coaxially from the  
11    lower surface. On the upper surface, a pivoting pointer 30 is positionable over a  
12    temperature indicia plate 40. The housing assembly 12 includes upper and lower  
13    portions rotatable with respect to one another, namely rotatable bezel 14 and  
14    lower housing 16. A rotatable ring 15 is circumferentially disposed between the  
15    rotatable bezel 14 and the lower housing 16 and is linked to the set temperature  
16    needle 32 so that the ring 15 can be manually rotated to select the alarm point on  
17    the indicia plate 40.             The construction of the housing 12 can best be seen in  
18    the cross-sectional view of the device 10 as shown in Fig. 2. Rotation of the  
19    rotatable bezel 14 with respect to the lower housing 16 winds an alarm spring 36  
20    disposed in the lower housing (Fig. 2). The skewer 18 is substantially hollow, and

1 has a sharpened distal end 19 adapted to penetrate meat to be cooked. A short  
2 linear segment of a shape memory alloy wire 20, preferably nickel titanium  
3 (nitinol) is disposed inside the skewer 18 and fastened to the distal end 19. The  
4 upper end of the nitinol wire 20 is secured to a connecting wire 24 having first  
5 and second ends 61, 62 which extends upwardly into the housing 12. The  
6 connecting wire 24 has a lower portion disposed in the skewer and an upper  
7 portion extending into the housing 12. Barrel crimps, such as barrel crimp 22,  
8 can be used to secure the ends of the nitinol wire 20 to the skewer and the  
9 connecting rod respectively. In the preferred embodiment the connecting wire 24  
10 is a wire cable, however any suitable type of wire can be used.

11 As can be best seen in Figs. 3D and 3E, the connecting wire 24 passes  
12 through a wire guide member 34 which is positioned in the housing 12. Referring  
13 again to Fig. 2, the wire guide member includes a curvilinear passage 35 which is  
14 adapted to allow sliding displacement of the connecting wire 24 therethrough.  
15 The connecting wire 24 extends upwardly coaxially out of the skewer into the  
16 wire guide member 34. The connecting wire 34 passes through the curvilinear  
17 passage 35 and extends out of the wire guide member 34 in a direction  
18 approximately normal to the skewer 18. The wire guide member 34 can have  
19 any suitable configuration which will allow the sliding displacement of the  
20 connecting wire 24 to redirect the orientation of the connecting wire 24 from the

1 vertical to approximately horizontal. In the preferred embodiment, the wire  
2 guide member 34 includes a cylindrical lower portion 37 adjacent to the skewer  
3 18 which has an aperture or through-bore 38 extending axially therethrough. The  
4 wire guide member 34 has an upper portion 39 having a curvilinear passage 35  
5 formed as a channel which is contiguous to the through-bore 38.

6 The second end of the connecting wire 24 is fixedly attached to a gear  
7 assembly rotatably mounted in the housing such that sliding displacement of the  
8 connecting wire 24 through the wire guide member 34 causes the rotation of the  
9 gear assembly. This rotation is transmitted to the pointer 30 through a  
10 cooperating spur gear train 31 which provides the appropriate gear ratio to move  
11 the pointer 30 through a predetermined arc for each degree change in temperature.

12 In the preferred embodiment, the gear assembly includes a sector gear 41 having  
13 a plurality of teeth arranged on an arcuate outer edge. The sector gear 41 is  
14 rotatably mounted on an eccentrically mounted shaft 64 withing the housing 12.

15 A projection 43 adapted for securement to the second end 62 of the connecting  
16 wire 24 extends diametrically from the sector gear 41. The projection 43 can  
17 include a first extension arm 51 integrally formed with the sector gear 41 and a  
18 second extension arm 63 coaxially mounted on the shaft 64 so as to tightly align  
19 with the first extension arm 51. In the illustrated embodiment, the second end 62  
20 of the connecting wire 24 terminates in a cable pull 33, and the connecting wire



1 24 is sandwiched between the first extension arm 51 and the second extension  
2 arm 63 and secured therein by cable pull 33. The second extension arm can  
3 include a hook 54 for engagement with a helical spring or other biasing means, as  
4 will be discussed in detail hereinafter.

5 When the skewer 18 and hence the nitinol wire 20 is heated, the nitinol  
6 alloy commences a phase transformation from martensite to austenite. In the  
7 preferred embodiment, the composition of the nitinol alloy is selected so that the  
8 transformation begins at approximately 140° F and is completed at approximately  
9 185° F, representing the span of temperatures required for cooking meat. The  
10 nitinol wire in the preferred embodiment is “70C nitinol” alloy. The nitinol wire  
11 in the preferred embodiment should measure approximately 2 inches in length and  
12 have a diameter of approximately 0.008 inches. Though the device 10 as  
13 described herein utilizes nitinol wire, any suitable shape memory wire alloy  
14 having the requisite phase transformation characteristics can be used.

15 During heating, as the phase transformation progresses from martensite to  
16 austenite, the nitinol wire contracts, smoothly and with significant force. (The  
17 nitinol wire of the preferred embodiment would provide sufficient force during  
18 the phase transformation to lift the equivalent of a 2 lb. object.)

19 One of the properties of shape memory wire alloys, e.g. nitinol wire, is that  
20 the overall temperature span of the transformation and the linearity of the change

1 in length versus temperature is a function of mechanical stress applied thereto. In  
2 the preferred embodiment, one of more springs of the appropriate length and  
3 spring constant are positioned to exert stress on the nitinol wire as it contracts, so  
4 that the stress exerted on the nitinol wire increases as the transformation  
5 progresses at a predetermined rate. In the preferred embodiment, a spring biasing  
6 means is applied to the gear assembly. The spring biasing means is constructed  
7 and arranged to exert stress on the nitinol wire 20 via the sector gear 41. The  
8 spring biasing means preferably has parameters configured to impart desired  
9 phase transformation characteristics to the nitinol wire 20 to optimize the  
10 austenite/martensite phase transition and the linearity of the temperature response.  
11 The spring biasing means is preferably a helical spring 28 tautly secured between  
12 the projection 43 and an anchor member 67. The helical spring can be formed  
13 from stainless steel. In an alternative embodiment, a plurality of helical springs  
14 can be attached to the sector gear 41, with each helical spring extending to an  
15 anchor member in a different location.

16 The increasing stress exerted by the spring 28 on the nitinol wire 20 as it  
17 contracts provides additional separation of  $A_F$  and  $M_F$ , the finish temperatures of  
18 the transformations to austenite and martensite respectively, thereby increasing  
19 the overall temperature span of the transformation so that the desired operating  
20 temperature can be achieved. Simultaneously, the increasing stress exerted by the

1 spring on the nitinol wire during the phase transformation improves the linearity  
2 of the change in length versus temperature. In the preferred embodiment the  
3 spring 28 is selected to have a free length of about 0.38", a spring constant of  
4 about 7.0 lb/in, a solid length of about .096" and a load at solid length of about  
5 1.7 lbs, which provides an operating temperature range of about 135° F to 190° F.  
6 In the practice of the invention, the spring 28 and nitinol wire 20 can each be  
7 specified to encompass parameters which would permit operation in a plurality of  
8 desired temperature ranges, so the device can be used to measure the temperature  
9 for a variety of different substances.

10 The maximum recoverable strain limit for both superelastic and shape  
11 memory nitinol is approximately 6 to 8%. However, in the preferred  
12 embodiment, to increase repeatability, the strain is limited to 4%. In the preferred  
13 embodiment, using 2 inch length of wire, 4% strain represents a movement of the  
14 wire and the connecting rod of 0.080 inches, which is sufficient to accomplish the  
15 desired purpose. Limiting the strain to 4% enables the heating/cooling cycle to be  
16 accurately repeated up to 100,000 times.

17 In another aspect of the invention, the position of the anchor member 67  
18 within the housing 12 can be altered to change the angle  $\alpha$  of the helical spring 28  
19 with respect to the sector gear 41. Changing the angle  $\alpha$  varies the degree of  
20 stress exerted on the sector gear 41 by the helical spring 28, and therefore adjusts

1 the phase transformation characteristics to the nitinol wire 20. The position of  
2 the anchor member 67 can thus be selected to adjust the temperature range of the  
3 cooking thermometer of the invention for a given application. The housing 12  
4 can include a plurality of anchor means, or voids for receiving the anchor means,  
5 so that the position of the anchor means 67 can be selected at the time of  
6 assembly.

7 Figs. 3A-E successively illustrate exploded views of the construction of the  
8 device 10. In Fig. 3A, rotatable bezel 14, rotating ring 15 and indicia plate 40  
9 have been removed. It can be seen that the set point needle is integrally formed  
10 with a set point disk 42 which includes a tab 44 which is attached to rotating ring  
11 15 (shown Fig. 1). The set point disk 42 includes a plurality of radially disposed  
12 apertures 45 which are configured to engage with cooperating protrusions 48 in  
13 the underlying trigger disk 47 (Fig. 3B) which is fixedly attached to the pointer 30  
14 such that the trigger disk 47 rotates with pointer 30. As seen in Fig. 3B, the  
15 trigger disk is biased upward by a leaf spring 50. The leaf spring 50 includes a  
16 first fixed end 52 and a second free end 53. The free end 53 includes downwardly  
17 depending lip portion which extends into a slot 55 (Fig. 3B). The apertures 45  
18 and the protrusions 48 are configured to be in engageable alignment when the  
19 pointer 30 and set point needle 32 coincide. When the pointer 30 reaches the set  
20 point needle 32, the protrusions are seated in the apertures, and the biasing force

1 of the leaf spring urges the trigger disk upward, thus releasing the lip portion of  
2 the leaf spring from the slot 55. Referring to Fig. 3D, it is seen that this motion  
3 releases a hammer and bell assembly 56 which is driven by ringer spring (not  
4 shown), and the alarm sounds. The phase transformation of the nitinol wire 20  
5 (Fig. 2) provides the force to rotate the trigger disk 47 and pointer 30, and thus the  
6 force necessary to trigger the bell and hammer alarm assembly 56.

7 The above-described preferred embodiment is inclusive of an audible  
8 spring-wound alarm, however in an alternative embodiment of the invention, the  
9 alarm assembly is omitted from the device 10. For such an embodiment, the  
10 rotatable bezel 14 could be omitted, and the temperature set point selected by  
11 rotation of the rotatable ring 15 with respect to the housing assembly 12.

12 All patents and publications mentioned in this specification are indicative  
13 of the levels of those skilled in the art to which the invention pertains. All patents  
14 and publications are herein incorporated by reference to the same extent as if each  
15 individual publication was specifically and individually indicated to be  
16 incorporated by reference.

17 It is to be understood that while a certain form of the invention is  
18 illustrated, it is not to be limited to the specific form or arrangement of parts  
19 herein described and shown. It will be apparent to those skilled in the art that  
20 various changes may be made without departing from the scope of the invention

1 and the invention is not to be considered limited to what is shown and described  
2 in the specification and drawings.

3 One skilled in the art will readily appreciate that the present invention is  
4 well adapted to carry out the objectives and obtain the ends and advantages  
5 mentioned, as well as those inherent therein. The embodiments, methods,  
6 drawings, procedures and techniques described herein are presently representative  
7 of the preferred embodiments, are intended to be exemplary and are not intended  
8 as limitations on the scope. Changes therein and other uses will occur to those  
9 skilled in the art which are encompassed within the spirit of the invention and are  
10 defined by the scope of the appended claims. Although the invention has been  
11 described in connection with specific preferred embodiments, it should be  
12 understood that the invention as claimed should not be unduly limited to such  
13 specific embodiments. Indeed, various modifications of the described modes for  
14 carrying out the invention which are obvious to those skilled in the art are  
15 intended to be within the scope of the following claims.